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ICESat (GLAS) Science Processing Software Document Series

Volume
Interface Control Document Between the I-SIPS/ISF and the CSR
Version 1.2

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Table of Contents

List of Tables

Section 1

Introduction

1.1 Identification of Document

This document provides the interface control for the exchange of files between:

- the ICESat Science Investigator-led Processing System (I-SIPS) and the Center for Space Research (CSR) at the University of Texas
- the GLAS Instrument Support Facility (ISF) and the Center for Space Research at the University of Texas.

It is a roll-out of Volume 1 (the Management Volume) of the four volumes of NASA software engineering documentation. Its parent document is the GLAS Science Data Management Plan [Reference: Parent Document 2.1b].

Subsequent versions of this document will be uniquely identified by document version and date marks on the cover and individual page footers.

1.2 Scope of Document

The scope of this document is to control all the GLAS-related file exchanges between the I-SIPS and the CSR, and between the ISF and the CSR.

1.3 Purpose and Objectives of Document

The objectives of this document are: (1) to define the data to be exchanged, and (2) to describe the mechanisms/control for the file exchange interface between the I-SIPS, the ISF and the CSR.

1.4 Document Organization

Sections 1 and 2 contain the introductory and reference document information. Section 3 contains the framework for the data exchange, and Section 4 identifies and describes the files to be exchanged.

Appendix A details the content and format of the files to be exchanged.

Supplemental information is presented in the Abbreviations and Acronyms and in the Glossary sections.

1.5 Document Status and Schedule

This document is the ICD between the I-SIPS/ISF and the CSR. Subsequent editions of the document will include updated file exchange and control information.

1.5.1 Items to be Resolved

The following items are to be resolved:

- The content and format of some files to be exchanged.

1.5.2 Document Change History

Document Name: Interface Control Document Between the I-SIPS/ISF and the CSR		
Version Number	**Date**	**Nature of Change**
0.0	January 1999	Initial Document
0.1	March 1999	Updated Information
0.2	May 1999	Updated Information
0.3	March 2000	Updated Information
0.4	August 2000	Updated Information
0.5	February 2001	Updated Information
0.6	May 2001	Updated Information
0.7	June 2001	Updated Information
0.8	August 2001	Updated Information
0.9	September 2001	Updated Information
0.10	October 2001	Updated Information
1.0	February 2002	Updated Information
1.1	November 2002	Updated Information
1.2	January 2003	Updated Information

Section 2

Related Documentation

This section provides the references for this interface control document. Document references include parent documents, applicable documents, and information documents.

2.1 Parent Documents

Parent documents are those external, higher-level documents that contribute information to the scope and content of this document. The following GLAS documents are parent to this document.

a) *GLAS Science Software Management Plan* (GLAS SSMP), NASA / TM-1999-208641 / Version 3 / Volume 1, July 1999, NASA Goddard Space Flight Center Wallops Flight Facility.

b) *GLAS Science Data Management Plan* (GLAS SDMP), NASA / TM-1999-208641 / Version 4 / Volume 2, July 1999, NASA Goddard Space Flight Center Wallops Flight Facility.

c) *GLAS Science Software Requirements Document* (GLAS SSRD), NASA / TM-2001-208641 / Version 2.1 / Volume 3, February 2001, NASA Goddard Space Flight Center Wallops Flight Facility.

d) *NASA Earth Observing System Geoscience Laser Altimeter System GLAS Science Requirements Document,* Version 2.01, October 1997, Center for Space Research, University of Texas at Austin.

The GLAS SSMP is the top-level Volume 1 (Management Plan Volume) document of the four volumes of NASA software engineering documentation [Applicable Reference 2.2c]. It dictates the creation and maintenance of the Data Management Plan. This document is a roll out of the Data Management Plan.

2.2 Applicable Documents

Applicable documents include reference documents that are not parent documents. This category includes reference documents that have direct applicability to, or contain policies binding upon, or information directing or dictating the content of this document. The following GLAS, EOS Project, NASA, or other Agency documents are cited as applicable to this interface control document.

a) *NASA Software Documentation Standard Software Engineering Program*, NASA, July 29, 1991, NASA-STD-2100-91.

b) *Science User's Guide and Operations Procedure Handbook for the ECS Project, Volume 4: Software Developer's Guide to Preparation, Delivery, Integration and Test with ECS,* Final, August 1995, Hughes Information Technology Corporation, 205-CD-002-002.

c) *Interface Control Document between the EOSDIS Core System (ECS) and the Science Investigator-Led Processing Systems (SIPS), Volume TBD, ICESAT Science Investigator-Led Processing System Data Flows* (DRAFT), February 2000, NASA Goddard Space Flight Center, 423-41-TBD.

d) *RS2000 Spacecraft to SRS Interface Control Document* (DRAFT), November 1999, Ball Aerospace & Technologies Corp. (BATC) Aerospace Systems Division, 545586.

e) *Precision Orbit Determination (POD)*, Algorithm Theoretical Basis Document, Version 2.2, October 2002, Center for Space Research, The University of Texas at Austin.

f) *Laser Footprint Location (Geolocation) and Surface Profiles*, Algorithm Theoretical Basis Document, Version 3.0, October 2002, Center for Space Research, The University of Texas at Austin.

g) *Precision Attitude Determination (PAD)*, Algorithm Theoretical Basis Document, Version 2.2, October 2002, Center for Space Research, The University of Texas at Austin.

h) *GLAS Level 0 Instrument Data Product Specification*, Version 2.2, March 17, 1998, NASA Goddard Space Flight Center Wallops Flight Facility.

i) *GLAS Standard Data Products Specification - Level 1*, Version 6.0, October 2002, NASA Goddard Space Flight Center Wallops Flight Facility.

j) *GLAS Standard Data Products Specification - Level 2*, Version 6.0, October 2002, NASA Goddard Space Flight Center Wallops Flight Facility.

k) *GLAS Science Computing Facility Interface Control Document*, Version 2.0, August 2001, Raytheon ITSS / Greenbelt, Maryland.

Section 3
Data Exchange Framework

The framework for the data exchange between the I-SIPS and the CSR will primarily be the same as defined for the ICESat Science Computer Facility (SCF). This software is designed to automate the transfer of files utilizing File Transfer Protocol, and to operate with user intervention at a minimum. See the SCF ICD for details.

The data exchange between the ISF and the CSR will generally be web-based or by e-mail.

Section 4
Data Flow Description

The data flow between the I-SIPS and the CSR is basically for the I-SIPS to routinely provide the CSR the required ICESat Level 1A data to compute precision orbits (POD) and precise pointing information (PAD) and for the CSR to provide these data back to the I-SIPS for routine level 1 B processing. The data flow between the ISF and the CSR provides additional information on the spacecraft and GLAS operations that are useful to the monitoring of events that affect the mission and POD / PAD computation.

Most of the data are transferred as standing orders or subscriptions. These data are supplied to the requester based on this ICD in an automatic transfer and unless problems occur do not require daily manual interaction between the centers. Some data seldom changes and these can be made available in a less automatic method.

The below subsections discuss the products that are supplied by each center to other centers.

4.1 Data Provided to the CSR

4.1.1 Files Transferred from the I-SIPS to the CSR

Most files provided by the I-SIPS will have keyword = value header records before the data records. There is a standard set of descriptions that provide the software version, date file was created, input files and other relative processing history. There are also specific key words on some files that provide information to the I-SIPS processing that only is relative to that product.

4.1.1.1 Laser Pointing Data File (GLA04)

GLAS Level 1A Standard Data Product GLA04 is comprised of the Stellar Reference System (SRS) data and other spacecraft data. The SRS is composed of the Laser Pulse Array (LPA), the Instrument Star Tracker (IST), the Laser Reference System (LRS) and the Gyro. Each GLA04 file is transferred from the I-SIPS to the CSR where it is used in the production of precision orbit and precision attitude files. The GLA04 product is composed of the following files:

- BST - data collected by the Ball Star Trackers (BST) 1 and 2.
- LPA - data consists of a 20x20 point image of each laser transmit pulse collected by the Laser Profiling Array with instrument calibration corrections applied. Transmit waveforms, time tag and record index are also included in each record.
- IST - data and images collected by the IST. This data is time aligned to LPA data.

- LRS - data collected by the LRS with instrument calibration corrections applied. This data is time aligned to the LPA data.
- GYRO - data collected by the gyro.
- Spacecraft Data - position and attitude data collected by the spacecraft.

Onboard the spacecraft, the SRS and related data are collected in the Position, Rate, and Attitude Packet (PRAP). The PRAP data are collected by the spacecraft bus and with data from the GPS receiver and the GLAS instrument are downlinked via the X-band. The PRAP is broken into files to create GLA04.

The contents and format of GLA04 are listed in Tables 3-1, 3-2, and 3-3 of Applicable Document 2.2i (*GLAS Standard Data Products Specification - Level 1*).

4.1.1.2 GPS Level 0 data

The GPS level 0 data (APID 1088) will be provided to CSR. This data is the raw GPS telemetry in the JPL receiver BLACKJACK format. It is identified as GLA00 file 1088.

4.1.1.3 GPS Time File (ANC32)

The GPS file created during Level 0 data processing that provides the GPS time and GLAS times at or near every GPS tick. The format is in Appendix A, Section A.7.

4.1.2 Data Provided by the ISF to the CSR

4.1.2.1 GLAS Instrument Operations Schedule (GLA SUP 01)

The GLAS Instrument Operations Schedule provides a list of instrument events and their planned execution times, and will be updated weekly. Planned spacecraft maneuvers are included in the schedule. This will be provided by a web view.

4.1.2.2 Event Log File (GLA SUP 12)

The Event Log File provides the listing of actual spacecraft events and their results. This will be provided by a web view and a downloadable file.

4.1.2.3 Spacecraft Data File (GLA SUP 08)

The Spacecraft Data File provides spacecraft data from Ball Flight Dynamics that the CSR requires. It includes DeltaV for maneuvers and center gravity changes. The format is TBD.

4.1.3 Summary of Data Provided to the CSR

Table 4-1 summarizes the parameters provided to the CSR by the I-SIPS and the ISF, for the CSR's computations of Precision Orbit Data (ANC08) and Precision Attitude Data (ANC09).

Table 4-1 Summary of GLAS Data Provided to the CSR

Application	Parameters	Elements	Source File	Source	Transfer Mechanism
Spacecraft Position	GPS Level 0 data (Blackjack format)	Carrier Phase L1, L2	GLA00 File 1088	I-SIPS	Pull
		Pseudorange L1, L2			
		GPS-System Time			
Laser Pointing (SRS)	Laser Profiling Array	LPA	GLA04 File 01	I-SIPS	Pull
		Altimeter Data (Shot Time, Raw Range, Hit QA, Transmitted Pulse)			
	Laser Reference System (LRS) data	LASER STAR CRS	GLA04 File 02	I-SIPS	Pull
	Gyroscope Data	GYRO	GLA04 File 03	I-SIPS	Pull
	Instrument Star Tracker	IST	GLA04 File 04	I-SIPS	Pull
Spacecraft Attitude and Position	Ball Star Tracker Data	BST	GLA04 File 05	I-SIPS	Pull
	Spacecraft Position, Velocity and Attitude	x, y, z Xdot, Ydot, Zdot Attitude Quaternions	GLA04 File 06	I-SIPS	Pull
Timing	GPS latched related time data GPS tick time data	• GPS Time • GLAS Frequency Board Counter • Time & Position Message Time • MET Time • Shot Number • Record Index	ANC32	I-SIPS	Pull
Instrument Operations	Instrument Operations Schedule	Short-Term Schedule of: • Instrument Events • Spacecraft Maneuvers	GLA SUP 01	ISF	WWW/file

Table 4-1 Summary of GLAS Data Provided to the CSR (Continued)

Application	Parameters	Elements	Source File	Source	Transfer Mechanism
	Event Log File	Executed: • Instrument Activities • Solar Array Start/Stop/ Freeze Times • Maneuver Periods• Spacecraft Rotations	GLA SUP 12	ISF	WWW/file
Spacecraft Position	Spacecraft Data	Orbital Parameters for Onboard Processing	GLA SUP 08	ISF	WWW/file
		DeltaV			
		Spacecraft Center-of-Gravity File			

4.2 Data Provided by the CSR

4.2.1 Data Transferred from the CSR to the I-SIPS

Most files provided by the CSR will have keyword = value header records before the data records. There is a standard set of descriptions that provide the software version, the date the file was created, input files and other relative processing history. There are also specific key words on some files that provide information to the I-SIPS processing that only is relative for that product.

4.2.1.1 Predicted Orbit Data (Ephemeris) File (ANC20)

The predicted orbit is produced in 48 hour time spans by the CSR and transferred to the I-SIPS daily where it is used to calculate the track numbers and granule start and stop times. The file will contain orbital positions of the ICESat center of gravity in the International Terrestrial Reference Frame (ITRF) and will contain 12 hours overlap in each direction surrounding the time span for which it is to be used. It will be received 24 hours before the time span for which the file is to be used. The contents and format are detailed in Appendix A, Section A.1.

4.2.1.2 Precision Orbit Data (Ephemeris) File (ANC08)

The Precision Orbit Data File is produced by the CSR, and transferred to the I-SIPS where it is used to geolocate Level 1B and Level 2 products. The File contains orbital positions of the GLAS altitude reference point at 30-second intervals, in the International Celestial Reference Frame (ICRF). The use of this file at the I-SIPS will require an interpolator (provided by I-SIPS). The time span will include 5 records before and after the time for which the file is to be used.

The file’s header will identify which input files were used for computing the precision orbit.The contents and format of this file are detailed in Appendix A, Section A.1.

4.2.1.3 Reference Orbit Data (Ephemeris) File (ANC26)

The CSR will provide Reference Orbit files to the I-SIPS. The Reference Orbit is the ideal exact repeat orbit. The Reference Orbit will be supplied in the ITRF in the same format as the predicted orbit file but the time tag will be relative to a zero reference time. It will be long enough to include all orbital revolutions of the spacecraft (hereafter referred to as tracks). The Reference Orbit file will be defined starting with a mode crossing (ascending or descending) and ending with a similar mode crossing. Use of ascending mode or descending mode will be with the mutual agreement of I-SIPS and CSR. The Reference Orbit File will include 5 records prior to the start of the exact repeat and 5 records at the end in order for I-SIPS to interpolate the ephemeris. The Reference Orbit will contain relative time tags.

The CSR will also provide the absolute times in UTC of the official beginning of an instance of a reference orbit. The times must be accompanied by the corresponding relative times within the appropriate reference orbit. An instance is defined as each time the spacecraft maneuvers into a new reference orbit. (i.e. if it starts out in the 8-day reference orbit that is instance 1 of the 8-day reference orbit, when it maneuvers into the 183-reference orbit that will be instance 1 of the 183 reference orbit, if it maneuvers back to within the mission-accepted tolerance of instance 1 of the 8-day reference orbit then that will be instance 2 of that orbit, etc.) The reference orbit beginning and ending time must be received with or before any data for that reference orbit can be properly processed at the I-SIPS. See Appendix A, Section A.1.

4.2.1.4 ICRF to ITRF Transformation File (ANC04)

This file contains polynomial coefficients to enable interpolation of the quaternions corresponding to the ICRF to ITRF transformation matrix. In summary, CSR computes quaternions from the transformation matrix, which are then approximated with polynomials. The polynomial coefficients are used to interpolate to any time within the file span, normally one day. I-SIPS will use the file to interpolate the quaternions to a required time, then reconstruct the ICRF to ITRF transformation matrix from the quaternions. Tests have shown the procedure maintains better than 12 decimal digits of accuracy in the transformation matrix elements.

4.2.1.5 JPL Planetary Ephemeris File (ANC41)

This file contains various planetary information for the years 2000 to 2040, extracted from JPL DE-405. This file will provide the ICRF position of the Sun for any time within 2000-2040. The contents and format of the file are described by Standish, et al, 1997 (JPL Planetary and Lunar Ephemerides, Willmann-Bell, Inc.). CSR will provide a program to I-SIPS to demonstrate the use of DE-405.

4.2.1.6 Precision Attitude Data File (ANC09)

The precision attitude file contains direction cosines in the ICRF defining the pointing direction of the laser with respect to GLAS optical bench axis and the laser ground footprint parameters at the shot resolution of approximately 40/sec. It also contains the GPS time, the time correction for each GPS tick, the record index, and flags denoting what data sources were used to calculate the parameters at the rate of approximately once per second (every 40 shots). The header information will denote periods of degraded attitude information (if they exist) within the data. This file will be used along with the precision orbit information and ITRF/ICRF rotation matrix and the range measurement to calculate the precise geodetic coordinates of the laser spot on the ground and the ground elevation. See Appendix A, Section A.3.

4.2.1.7 GLAS GPS Receiver Data File (ANC39)

- GPS - Global Positioning System data in Receiver-Independent Exchange (Rinex) format will be organized into one day files, ready for use in the POD and for archive. The one day interval is defined from midnight to midnight, GPS-time.

4.2.1.8 POD Center of Gravity-to-Laser Reference File (ANC37)

The Center of Gravity-to-Laser Reference File contains vector distances which relate the spacecraft center of gravity to the laser measurement reference. This file is updated when required, typically after an orbit maneuver.

4.2.1.9 GPS-to-UTC Leap Second File (ANC25)

The GPS-to-UTC Correction File contains the date/times of leap seconds, used in the conversion of the GPS time to the UTC time. This file will be updated about once per year.

4.2.1.10 Software

Transformation Matrix and Solar Position Software

The CSR will provide to the I-SIPS software to import the JPL Planetary Ephemeris file and compute the Sun position vector in ICRF.

The software required to compute the ICRF to ITRF transformation matrix from the quanternion interpolation file will be provided by CSR.

Precision Attitude Data Software

The CSR will provide a copy of the software that produces the Precision Attitude Data (PAD) for the I-SIPS. Any PAD software updates affecting the GLAS-related output will cause a new delivery of the entire software package.

Software Change Notices

The CSR will provide copies of any relevant POD and PAD Software Change Notices, the nature of which may affect the precision orbit data, precision attitude data, or other data provided to the I-SIPS or the ISF. The change request that implemented the updated software will be approved by the ICESat Software CCB.

4.2.2 Summary of Data Provided by the CSR

Table 4-2 summarizes the parameters provided by the CSR.

Table 4-2 Summary of Data Provided by the CSR

Application	Parameters	Elements	Source File	Destination	Transfer Mechanism
Granule Times, Geolocation	Predicted Orbit	Position/velocity in ITRF	ANC20	I-SIPS	Push
Geolocation	Precision Orbit Data	Position/velocity in ITRF	ANC08	I-SIPS	Push
Track Designation	Reference Orbit	Position/velocity in ITRF	ANC26	I-SIPS	Push
Computing ICRF to ITRF Transformation matrix	Equivalent quaternions	Polynomial coefficients	ANC04	I-SIPS	Push
Computing Sun position	JPL Planetary Ephemeris DE-405	Polynomial coefficients	ANC41	I-SIPS	Complete

Table 4-2 Summary of Data Provided by the CSR (Continued)

Application	Parameters	Elements	Source File	Destination	Transfer Mechanism
Instrument Position	POD Spacecraft Center of Gravity- to- Laser Reference	Vector Distance as Function of Date	ANC37	I-SIPS	Push
Precision Off-Nadir Angles and Time Correction	Precision Attitude Data	Pointing Vectors	ANC09	I-SIPS	Push
	Pulse Information	Orientation, Semi-Major/ Semi-Minor Axes, Intensity			
	GPS Time Correction	Microsec of Correction to be Added to GPS Time			
Timing (GPS-to-UTC)	Leap Second Table	Dates/Times of Leap Seconds	ANC25	I-SIPS	Push
Position Data	GPS Data (RINEX Format)	Carrier Phase L1, L2	ANC39	I-SIPS	Push
		Pseudorange L1, L2			
		GPS-System Time			
Configuration Management	Transformation Software	Software and Documentation	DAP	I-SIPS	Push
	Precision Attitude Data Software	Software and Documentation	DAP	I-SIPS	Push
	Software Change Request			CCB	Fax, WWW, and email
	Software Change Notices	N/A	N/A	I-SIPS	Fax, WWW, and email

Appendix A
File Contents and Formats

Most ICESat (GLAS) data products have header information preceding the actual data records. This header information contains metadata-like parameters that document the production history of that product. These parameters are written in ASCII keyword = value format, each one delimited by a semicolon and linefeed. Some of parameters such as those defining file creation date, creating program version, and input file names are common to all products and are listed in Table A-1. These are referred to as standard header keywords. Other keywords are specific to their respective products and are defined in the product-specific sections of this appendix.

ICESat files are direct access files and to be read in Fortran 90 must have records of constant record length throughout the file. Note that direct access unformatted files have no record delimiters. Data records for some of the files are very short and do not allow for the keyword=value to fit within the record length. To overcome this and still have header information, the total header information must be an integer multiple of the data record length in bytes. To be able to list the header information easily "keyword=value" is delimited by a ";" (semicolon) and a linefeed, so that if one does a simple UNIX command on the file, "strings gla01.dat | more" the contents of header records will scroll down the screen or output into a file one "keyword=value" at a time. The first parameter is always the record length of the data record, Recl. The second parameter is the number of Recl length records used to write the header information.

For example, if the data record length is 64 bytes and we have only the following 3 keywords in our header (this is not a realistic case since the standard header keywords are present in all files, unless stated otherwise, contain many more keywords).

Keyword	Value
RECL	Data record length in bytes
NUMHEAD	No. of recl length records used to write the header information
LOCALGRANULEID	File name, following the GLAS naming convention

The data file would contain 128 bytes of information for the header, 71 bytes of actual information padded out to 128 so it is an integer multiple of Recl which is 64. It would look like:

Recl=64;lfNumhead=2;lfLocalGranuleID=ANC08_001_20010701_000000_01_00.dat;lf

^^^^^^^^^data record 1 … (64 bytes) data record 2 …

where lf is a line feed

^ denotes padding of 1 byte

Table A-1 Standard Header Keywords

Keyword	Value or description
RECL	Record length of data record
NUMHEAD	No. of Recl length records used to write the header information
LOCALGRANULEID	File name following GLAS naming convention
SIZEMBECSDATAGRANULE	File size in Mbytes
PRODUCTIONDATETIME	yyyy/mm/dd-hh:mm:ss- time the file was produced
SHORTNAME	Short name for the file type
VERSIONID	Version number for the format of this file
INPUTPOINTER	Input data files used to create product [see Footnote 1)
BEGINNINGTIME	hh:mm:ss in GPS - Time
ENDINGTIME	hh:mm:ss in GPS - Time
BEGINNINGDATE	yyyy/mm/dd in GPS - Time
ENDINGDATE	yyyy/mm/dd in GPS - Time
PGEVERSION	Version number of program(s) that created this product [see Footnote 2]
ANCILLARYINPUTPOINTER	Ancillary input file names (if needed) [see Footnote 1]
INSTRUMENTSHORTNAME	GLAS
PLATFORMSHORTNAME	ICESat
DOCUMENTATION	Reference to UTCSR file documentation
FILE_FORMAT	Fortran format of data record

Note 1: This keyword is repeated once for each input data file

Note 2: PGEVERSION can be repeated if needed to show the version number of software that actually created the file and the version number of the orbit and /or attitude determination software that created the preliminary file.

A.1 Precision Orbit Data File (ANC08), Predicted Orbit Data File (ANC20), Reference Orbit Data File (ANC26)

Precision Orbit Data File

The file will be ANC08_mmmyyymmdd_hhmmss_nn_ffff.eee.

The following Rules will apply:

- This file will be named following the GLAS naming convention ANC08_mmm yyyymmdd_hhmmss_nn_ffff.eee where
    - mmm-release number for process that created the product (CCB assigned-combination of software and data)
    - yyyymmdd – start date in year, month, and day of month for period to use file (first point after overlap)
    - hhmmss – start time hour, minute, second for period to use file (first point after overlap)
    - nn- granule version number (the number of times this granule is created for a specific release)
    - ffff- file type (numerical, CCB assigned for multiple files as needed for data of same time)
    - period for a specific HHHxx,.i.e. multi-file granule)
    - eee- file extension – dat, scf, hdf,eds,pds,met, ctl
- The time system is GPS
- The position and velocity vectors are given in the International Celestial Reference Frame
- Standard Header keywords will be at the beginning of the file, followed by the specific header keywords described in Table A-2.
- The files are direct access, IEEE, binary with data records of 64 bytes and header information that is contained in n*64 bytes where n is an integer
- The duration of each file is nominally 24 hrs starting 5 records before and continuing through 5 records after the 24 hrs for which the data is to be used
- The time between data records will nominally be 30 seconds, but is in the header information and can be changed with agreement from both parties.

Table A-2 Specific Header Keywords (Precision Orbit)

Keyword	Description
TIME_SYSTEM	GPS, Time system of time in data records
FILE_CONTENT	Days/ispare/sec/pos_vector/vel_vector

Table A-2 Specific Header Keywords (Precision Orbit) (Continued)

Keyword	Description
EPOCH_YR	4 digit epoch year
EPOCH_MO	2 digit epoch month
EPOCH_DAY	2 digit day of month of epoch
EPOCH_SECONDS	Starting integers seconds of day of epoch
DELTAT	Time increment in integer seconds between position vectors
DURATION	Integer number of seconds covered
The following keywords define the intended start and end times, thus the overlap points are not included.	
USEBEG _MO	Specifies start month
USEBEG _DAY	Specifies start day
USEBEG _SEC	Specifies start seconds
USEBEG _MO	Specifies start month
USEBEG _DAY	Specifies start day
USEBEG _SEC	Specifies start seconds
The following 3 keywords are repeated as a set for as made orbit degradation periods that exist in the file	
DEGRADE_START	Starting second from epoch for a period of orbit degradation
DEGRADE_STOP	Stopping second from epoch for a period of orbit degradation
DEGRADE_REASON	Reason for orbit degradation for the time period defined on the keywords which immediately precede this keyword
MISSING_GPS	Used to identify periods when GPS data is unavailable (e.g., receiver reset).This does not necessarily imply that the orbit quality is degraded.
MISSING_SA	Used to identify periods when solar array orientation data is unavailable from the GLA04 files. Nominal model will have been substituted. This does not necessarily imply that the orbit quality is degraded.
MISSING_ATT	Used to identify periods when attitude data is unavailable from the GLA04 files or from PAD. Nominal model will have been substituted. This does not necessarily imply that the orbit quality is degraded.
MANEUVER	Used to identify periods when the solutions before and after a maneuver have been blended. The resulting solution during this period should be used with some caution.

Table A-2 Specific Header Keywords (Precision Orbit) (Continued)

Keyword	Description
MODEL_PROBLEM	Used exclusively to indicate that the radial orbit accuracy requirement has not been met for the arc; i.e., assessed to be in excess of 5 cm. Since this can only be evaluated in an RMS sense, the interval identified would, by definition, be the entire arc. The general nature of the term covers various possible explanations that may be undetermined at the time of processing, ranging from poor quality GPS data to unmodeled dynamic events, such as outgassing.
Note: See Table A-3 for data format. Epoch time and duration refer to the actual start and stop times of the files.	

Table A-3 Data Record Format

Parameter	Type	Units	First Byte Number
MJD	Integer*4	Days	0
POD flag	4 bytes	N/A	4
TSEC	Real*8	seconds	8
X	Real*8	meters	16
Y	Real*8	meters	24
Z	Real*8	meters	32
Xdot	Real*8	Meters/second	40
Ydot	Real*8	Meters/second	48
Zdot	Real*8	Meters/second	56

The corresponding values for the ISPARE field in each data record that falls within the time span covered by DEGRADE_START and DEGRADE_STOP would then be:

0 = nominal

1 = missing data (identified explicitly by the DEGRADE_REASON)

2 = maneuver

3 = modeling problem

Predicted Orbit File

This will follow the same rules as the precision orbit file with the following exceptions.

- The name will be ANC20_mmmyyyymmdd_hhmmss_nn_ffff.eee
- The position and velocity vectors will be given in the ITRF
- Standard Header keywords will be at the beginning of the file, followed by the specific header keywords described in Table A-4.

Table A-4 Specific Keywords for Predicted Orbit File

Keyword	Description
TIME_SYSTEM	GPS, Time system of time in data records
FILE_CONTENT	Days/ispare/sec/pos_vector
EPOCH_YR	4 digit epoch year
EPOCH_MO	2 digit epoch month
EPOCH_DAY	2 digit day of month of epoch
EPOCH_SECONDS	Starting integers seconds of day of epoch
DELTAT	Time increment in integer seconds between position vectors
DURATION	Integer number of seconds covered
Note: See Table A-3 for data format.	

Reference Orbit File

This will follow the same rules as the precision orbit file with the following exceptions.

- The name will be ANC26_mmmyyyymmdd_hhmmss_nn_ffff.eee
- The position and velocity vectors will be given in the ITRF
- Standard Header keywords will be at the beginning of the file, followed by the specific header keywords described in Table A-5
- The time will be relative time, to the beginning of the file
- Each reference orbit file includes 5 data records before the first ascending mode of the first orbit (track).

Table A-5 Specific Keywords for Reference Orbit File

Keyword	Description
TIME_SYSTEM	GPS, Time system of time in data records
FILE_CONTENT	Days/ispare/sec/pos_vector
DELTAT	Time increment in integer seconds between position vectors
DURATION	Integer number of seconds covered
Note: See Table A-3 for data format.	

A.2 ICRF to ITRF Transformation Interpolation File (ANC04)

This file is used to compute the ICRF to ITRF transformation matrix for any time within the time span represented by the file contents. The file contains polynomial coefficients that represent the corresponding transformation matrix quaternions. The file follows the following rules:

1) This file will be named ANC04_mmmyyymmdd_hhmmss_nn_ffff.eee, where the interpretation of the quantities is given in the ANC08 description.

The file characteristics are:

1) the file is a direct access, IEEE-binary format
2) each record contains one second of quaternion polynomial coefficients for interpolation
3) the header information contains the standard header keywords listed in Table A-1
4) the file has no overlap interval with other ANC04 files

A.3 Precision Attitude Data File (ANC09)

The file will be ANC09_mmmyyymmdd_hhmmss_nn_ffff.eee.

The file will be comprised of time, unique rec index, GPS time, GPS time correction, 40 pointing vectors of quality flag and laser pulse shape

1) Each record contains approximately one second of information (40 laser shots). There are 40 vectors in each record.
2) The record index is from the Laser Profiling Array (LPA) of GLA04.
3) The header information contains the standard header keywords listed in Table A-1 and the specific header keywords listed in Table A-6

4) The file has no overlap interval with other ANC09 files.

Table A-6 Specific Header Keywords (Precision Attitude Product)

Keyword	Description
Time_System	GPS, Time system of time in data records
File_Content	Index/flag/Days/ispare/sec/pos_vector
Epoch_yr	4 digit epoch year
Epoch_mo	2 digit epoch month
Epoch_day	2 digit day of month of epoch
Epoch_seconds	Starting integers seconds of day of epoch
Deltat	Time increment in integer seconds between position vectors
Duration	Integer number of seconds covered
The following 3 keywords are repeated as a set for as made attitude degradation periods that exist in the file	
Degrade_start	Starting second from epoch for a period of attitude degradation
Degrade_stop	Stopping second from epoch for a period of attitude degradation
Degrade_reason	Reason for attitude degradation for the time period defined on the keywords which immediately precede this keyword)
MISSING_LPA	no LPA data
NOISY_LPA	LPA exhibits excessive noise or other problems
MISSING_LRS	no LRS data
LRS_NOSTAR	no star data in LRS for more that 10 minutes
LRS_NOLASER	no laser data in LRS
LRS_NOCRS	no CRS data in LRS
NOISY_LRS	LRS exhibits excessive noise
MISSING_GYRO	no gyro data
NOISY_GYRO	gyro exhibits excessive noise
MISSING_IST	no IST data
NOISY_IST	IST exhibits excessive noise
MANEUVER	maneuver occurred

It does not follow automatically that the PAD will be degraded with any one of the above keywords.

For the individual pointing sigma (ps):

ps= 0.0 Good

ps= 1.0 Bad

ps > 0.0 & ps < 1.0: scaled degradation

The document referred to in the header will provide a summary of the data used(e.g., the ground GPS stations), identify anomalies, summarize the characteristics of the respective solution, etc.

Once per second information in first part of record.

Table A-7 ANC09 Data Record (once per second)

Parameter	Type	Units	First Byte Number
Record Index	Integer*4	Counts	0
Instrument Flag	Integer*4	Flag	4
GPS Time (Latched Value)	Real*8	Seconds	8
GPS Time Correction	Real*8	Seconds	16

The instrument flag defines the data sources used such as (Laser, LRS, LPA, IST, GYRO, BST1, BST2) 40 per second information in last part of record. The GPS time (Latched Value) is the once per ten second GPS time value that was captured by GLAS and is provided in GLA04-01 LPA file. This GPS time is used for all time computations related by the specific record index. GPS Time Correction is defined to be additive to GPS Time (Latched Value).

Forty per second information follows as the second part of record (n=1 to 40):

Table A-8 ANC09 Data Record (forty per second)

Parameter	Type	Units	First Byte Number
MJD	Integer*4	Days	24+72 (n-1)
Spare	4 bytes	N/A	28+72 (n-1)
TSEC	Real*8	Seconds	32+72 (n-1)
Cosine α	Real*8	Unitless	40+72 (n-1))
Cosine β	Real*8	Unitless	48+72 (n-1)
Cosine γ	Real*8	Unitless	56+72 (n-1)
Pointing Sigma	Real*8	Arcsec	64+72 (n-1)
Spare	4 bytes	N/A	72+72(n-1)
Pulse Orientation (Azimuth measured from North)	Real*4	Degrees	76+72 (n-1))

Table A-8 ANC09 Data Record (forty per second)

Pulse Major Axis	Real*4	Meters	80+72 (n-1))
Eccentricity	Real*4	Unitless	84+72 (n-1)
Pulse Intensity	Real*8	Counts	88+72 (n-1)

A.4 POD Spacecraft Center of Gravity File (ANC37)

The header information contains the standard header keywords. See Table A-1. The format of the data record is given in Table A-9.

Table A-9 ANC37 Data Record

Parameter	Type	Units	First Byte Number
TBD			

GPS-time (start time of new center of gravity terms) x, y, z of center of gravity location at GPS-time. Applies until next center of gravity change.

A.5 GPS to UTC Leap Second File (ANC25)

The ANC25 file will contain:

GPS time at which the given leap second correction will be applied for the first time correction; MJD and TSEC form of time to apply correction; year, month and day form of time to apply correction, total leap seconds correction to apply.

The file is in ASCII text format, delimited by spaces and contains no header records. The file allows comments (Text preceded by the # character). This file is expected to be transferred no less than one per year.

Table A-10 ANC25 Data Record

Parameter	Type	Units	First Byte Number
MJD	char*8	mmddyyyy	24
TSEC	char*24	Seconds	0
Total Leap Seconds	char*8	Seconds	32

A.6 Spacecraft Data File (GLA SUP 08)

File Contents and Format are TBD.

A.7 GPS Time File (ANC32)

Due to the small record length, the ANC 32 file contains a limited subset of the standard header entries:

Table A-11 Specific Header Keywords (GPS Time File)

Key word	Description
Recl	record length
Numhead	number of header records
NumData	number of data records
DataStart	data start time in UTC seconds
DataStop	data stop time in UTC seconds

:

Table A-12 ANC32 Data Record

Parameter	Type	Units	First Byte Number
Record Index number (APID 19 when GPS time changed)	Integer*4	10ths of seconds	0
Shot number (near Time and Position message received)	Integer*4	counts	4
UTC Time (APID 19 secondary header time when GPS changed)	Real*8	UTC seconds	8
Frequency board counter (latched at GPS tick) BVTCW latch to GPS	Real*8	counts	16
MET near time and position message	Real*8	UTC seconds	24
S/C time (at time and position message)	Real*8	UTC seconds	32
GPS time	Real*8	GPS seconds	40
MET near GPS tick	Real*8	UTC seconds	48
S/C time (at GPS tick)	Real*8	UTC seconds	56

Abbreviations & Acronyms

BST	Ball Star Tracker
CSR	Center for Space Research at the University of Texas
DAAC	Distributed Active Archive Center
ECS	EOSDIS Core System
EDOS	EOS Data and Operations System
EOC	EOS Operating Center
EOS	NASA Earth Observing System Mission Program
EOSDIS	Earth Observing System Data and Information System
GLAS	Geoscience Laser Altimeter System instrument or investigation
GPS	Global Positioning System
GSFC	Goddard Space Flight Center
GSFC/WFF	Goddard Space Flight Center/Wallops Flight Facility
ICRF	International Celestial Reference Frame
ID	Identification
ICESat	Ice, Cloud, and Land Elevation Satellite
IEEE	Institute for Electronics and Electrical Engineering
ISF	Instrument Support Facility
IST	Instrument Star Tracker
ITRF	International Terrestrial Reference Frames
LASER	Light Amplification by Stimulated Emission of Radiation
LIDAR	Light Detection and Ranging
LPA	Laser Profiling Array
LRS	Laser Reference System
N/A	Not (/) Applicable
NASA	National Aeronautics and Space Administration
NOAA	National Oceanic and Atmospheric Administration
PAD	Precision Attitude Determination
POD	Precision Orbit Determination

PRAP	Position, Rate, and Attitude Packet
RINEX	Receiver-Independent Exchange format
SCF	Science Computing Facility
SDPS	Science Data Processing Segment
SIRU	Space Inertial Reference Unit
SRS	Stellar Reference System
TBD	to be determined, to be done, or to be developed
UNIX	the operating system jointly developed by the AT&T Bell Laboratories and the University of California-Berkeley System Division
UTC	Coordinated Universal Time

Glossary

file	A collection of data stored as records and terminated by a physical or logical end-of-file (EOF) marker. The term usually applies to the collection within a storage device or storage media such as a disk file or a tape file. Loosely employed it is used to indicate a collection of GLAS data records without a standard label. For the Level 1A Data Product, the file would constitute the collection of one-second Level 1A data records generated in the SDPS working storage for a single pass.
header	A text and/or binary label or information record, record set, or block, prefacing a data record, record set, or a file. A header usually contains identifying or descriptive information, and may sometimes be embedded within a record rather than attached as a prefix.
label	The text and/or binary information records, record set, block, header, or headers prefacing a data file or linked to a data file sufficient to form a labeled data product. A standard label may imply a standard data product. A label may consist of a single header as well as multiple headers and markers depending on the defining authority.
Level 0	The level designation applied to an EOS data product that consists of raw instrument data, recorded at the original resolution, in time order, with any duplicate or redundant data packets removed.
Level 1A	The level designation applied to an EOS data product that consists of reconstructed, unprocessed Level 0 instrument data, recorded at the full resolution with time referenced data records, in time order. The data are annotated with ancillary information including radiometric and geometric calibration coefficients, and georeferencing parameter data (i.e., ephemeris data). The included, computed coefficients and parameter data have not however been applied to correct the Level 0 instrument data contents.
Level 1B	The level designation applied to an EOS data product that consists of Level 1A data that have been radiometrically corrected, processed from raw data into sensor data units, and have been geolocated according to applied georeferencing data.
Level 2	The level designation applied to an EOS data product that consists of derived geophysical data values, recorded at the same resolution, time order, and georeference location as the Level 1A or Level 1B data.
Level 3	The level designation applied to an EOS data product that consists of geophysical data values derived from Level 1 or Level 2 data, recorded at a temporally or spatially resampled resolution.
Level 4	The level designation applied to an EOS data product that consists of data from modeled output or resultant analysis of lower level data that are not directly derived by the GLAS instrument and supplemental sensors.

metadata	The textual information supplied as supplemental, descriptive information to a data product. It may consist of fixed or variable length records of ASCII data describing files, records, parameters, elements, items, formats, etc., that may serve as catalog, data base, keyword/value, header, or label data. This data may be parsable and searchable by some tool or utility program.
product	Specifically, the Data Product or the EOS Data Product. This is implicitly the labeled data product or the data product as produced by software on the SDPS or SCF. A GLAS data product refers to the data file or record collection either prefaced with a product label or standard formatted data label or linked to a product label or standard formatted data label file. Loosely used, it may indicate a single pass file aggregation, or the entire set of product files contained in a data repository.
Standard Data Product	Specifically, a GLAS Standard Data Product. It represents an EOS ALT-L/GLAS Data Product produced on the EOSDIS SDPS for GLAS data product generation or within the GLAS Science Computing Facility using EOS science community approved algorithms. It is routinely produced and is intended to be archived in the EOSDIS data repository for EOS user community-wide access and retrieval.